Zooplankton and Ichthyoplankton Vertical Distribution on the Nova Scotia Shelf and their Relationship to 120 kHz Acoustic Scattering Layers

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Fisheries and Marine Service

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by

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ABSTRACT

Sameoto, D.D. and M.K. Lewis. 1979. Zooplankton and ichthyoplankton vertical distribution on the Nova Scotia Shelf and their relationship to 120 kHz acoustic scattering layers. Fish. Mar. Serv. Tech. Rept. 890: v + 43 p.

Zooplankton and ichthyoplankton samples were taken on the Nova Scotia Shelf in regions of acoustic scattering layers with the aim of determining the relationships between the different species of animals and the presence and intensity of the scattering layers as well as the vertical distribution of the animals with time over 24 h. The value of acoustics in detecting and quantitatively measuring zooplankton concentrations is discussed.

RÉSUMÉ

Sameoto, D.D. and M.K. Lewis. 1979. Zooplankton and ichthyoplankton vertical distribution on the Nova Scotia Shelf and their relationship to 120 kHz acoustic scattering layers. Fish. Mar. Serv. Tech. Rept. 890: v + 43 p.

On a prélève des échantillons de zooplancton et d'ichthyoplankton dans des zones de couches de dispersion acoustique du plateau continental néo-écossais dans le but de déterminer les rapports qui existent entre les diverses especes d'animaux et la présence et l'intensité des couches de dispersion acoustique ainsi que la distribution verticale des animaux par rapport au temps, pendant une periode de 24 heures. On discute de la valeur de l'acoustique pour la détection et la mesure quantitative des concentrations de zooplancton.

INTRODUCTION

The purpose of this study was to observe the vertical distribution of zooplankton and ichthyoplankton using a 120 kHz sounder and biological samples. The samples were used to evaluate the usefulness of the sounder as an instrument to routinely locate and quantitatively estimate zooplankton and ichthyoplankton abundances. Different areas of the Nova Scotia Shelf were sampled (Fig. 1) with the aim of locating different concentrations of zooplankton and ichthyoplankton.

METHODS

A Simrad Scientific EK 120 Sounder with a frequency of 120 kHz was used in the study. The transducer was mounted in a 2-foot Braincon V-fin towed from the side of the ship at a depth of 3 m along a series of transects over the shelf at a speed of 6 knots observing the presence and depth of acoustic scattering layers. When areas of interest were observed biological samples were taken simultaneously with the acoustic measurements.

The reader is directed to Sameoto (1979) for a complete description of the methods of handling the acoustic data. The acoustic data given in this report are the squared voltages and calculated volume scattering in dB values of the returning echos from biological acoustic scattering layers. The echograms for all the tows were recorded at a fixed sounder setting as follows:

Pulse length	1 msec
Pulse rate	48 per minute
Beam width	9°(between 3 dB pts)
Bandwidth	9.9 kHz
Transmitter	1/1(91 dB/1 µBar per watt ref. 1 m)
Recorder gain	8
Discriminator	4
Range	0 to 250 m

The biological samples were taken with a multiple-net sampler (Sameoto et al., 1977) with 9 one m^2 mouth opening nets with a mouth to surface filtering area ratio of 1:10. During tow #1 the mesh size for even numbered nets was 1050 µm and the odd numbered nets were 243 µm, for all other tows the mesh size was 243 µm for all nets except net #2 which was 1050 µm. All nets contained a General Oceanics flowmeter tied in the mouth which started to count when the net opened and stopped counting when the net was closed. The nets of the sampler were opened and closed on command from the ship as the sampler was raised obliquely to the surface from the greatest depth. Each net was towed approximately 4 to 5 minutes at a speed of 3 knots filtering about 300 m^3 of water. As one net closed the next net opened sequentially. The sampler also continuously measured temperature during the entire tow. The depth range for each net is given in Table 1.

The samples were preserved in a buffered 5% formalin and sea water solution. The entire sample was examined for ichthyoplankton and macrozooplankton larger than 10 mm, which were removed, counted, identified, measured and wet weighed. The remaining sample was drained of formalin solution and wet weighed to obtain the biomass weight. The sample was then placed back in the formalin solution and split a number of times and one of the split portions from each sample sent to the Canadian Oceanographic Identification Centre, National Museum of Natural Sciences in Ottawa for complete identification and enumeration.

RESULTS

Temperature profile

The temperatures (Table 1) given are the mean values over the depth range of the samples, therefore the depth of the thermocline (Fig. 2) is approximate. The thermocline depth varied from about 20 m to 58 m on the different stations. The maximum temperature was 18.4 C on station 5 and the minimum temperature was 2.0°C found at 40 to 48 m on station 1.

There was a general increase in the biomass of zooplankton and the number of copepods per m^3 (Table 1a) at the thermocline, and except for station 11 a decrease in biomass in the warmer surface water. All species of copepods decreased in abundance above the thermocline except *Centropages typicus* which increased (Fig. 2).

The fish larvae showed a similar pattern to the zooplankton, being most abundant at the thermocline region (Fig. 2).

Vertical migration

There was no evidence of a systematic change in the zooplankton biomass with depth during the day or night (Fig. 2). But individual species did show a distinct vertical migration pattern. These species were *Pseudocalanus minutus*, *Metrida lucens* and *M.* sp., *Centropages typicus*, *Paracalanus parvus*, *Sagitta elegans* and the fish larvae *Glyptocephalus cynoglossus* (Fig. 2).

There was no significant depth change with time for the other species of zooplankton and fish larvae.

Acoustic echogram interpretation

Acoustic backscattering can be caused by a variety of organisms ranging from large fish to concentrations of copepods. The zooplankton that are most likely to result in intense backscattering are those with the greatest density difference from sea water. These include the

siphonophores with their gas bubles, euphausiids and amphipods because of their exoskeletons, and fish larvae with their ai bladders. Copepods will also cause a significant echo if they are highly concentrated. Barraclough et al. (1969) recorded a layer of the copepod *Calanus cristatus* with a density of 150 m^{-3}. Except for individual fish it is impossible to tell from the echogram or the voltage of the echo what tne source of the backscattering is without taking net samples of the animals from the acoustic scattering layers. But even the biological samples do not ensure positive identification of the scatterer, since uncertainty always remains that the net captured the organisms responsible for the backscattering. The uncertainty can be reduced by estimating the volume backscattering (S_v) from the types and numbers of animals per m^3 and their target strengths (TS) and comparing this to the value of S_v calculated from the voltage. Theoretically the two S_v values should be the same if all the animals causing backscattering in each m^3 are captured and it is assumed the animals are all orientated horizontally.

Kaye (1978) estimated the target strength of a number of organisms at 87.5 kHz. He estimated that siphonophores with a bubble ranging in size from .25 to 4.94 mm^3 would have a target strength ranging from -67 to -59 dB. The target strength of small euphausiids was estimated to be about -75 to -80 dB and that of copepods about -100 dB. A 35 mm fish in the dorsal aspect was estimated to have a target strength of around -55 dB. The target strength of fish larvae between 10 and 20 mm is not known but it likely falls between -55 and -80 dB. It is recognized that at 120 kHz the same animals may have slightly different target strengths, but considering the approximate nature of this study these values were considered adequate for the S_v estimates.

A scattering layer was found near or above the thermocline at all the stations even though the intensity of the layer varied on the different stations (Fig. 3). Stations 3, 6, 9 and 10 all had a pronounced layer near the bottom which when sampled showed siphonophores present. The organisms believed responsible for the acoustic scattering on the different stations are listed in Table 2.

The S_v were calculated from the measured backscattering voltage and from the numbers and TS of animals collected at the different depths. These two results for S_v were compared to indicate if significant scatterers were not being caught. It must be emphasised that there is very little data on the TS of different zooplankton species and sizes of zooplankton. Therefore these calculations can only be considered as the rough estimates. Equation (1) was used to calculate S_v from the voltage and equation (2) to calculate S_v from the animal number and target strength.

$$S_v = 20 \log V - 55.7 \qquad (1)$$

where V = measured acoustic backscattering voltage
-55.7 = is a constant in dB for the sounder and electronic recording equipment.

The S_v calculated using equation (1) for each of the samples is given in Table 3.

$$S_v = 10 \log n + TS \qquad (2)$$

where: n = number of animals m^{-3}
TS = target strength of one animal in dB.

$$V = \text{antilog}_{10} \frac{(10 \log n + TS + 55.7)}{20} \qquad (3)$$

To estimate the total S_v due to a variety of animal types with different target strengths the value of V was calculated from the S_v for each type of animal using equation (3) and summed. Then from the summed V an estimate of the S_v caused by all the animals was calculated using equation (1). For the calculations of S_v given in Table 2 it was assumed that the target strengths of the different groups of animals in a horizontal orientation were:

Sagitta and copepods (such as *Calanus*)	- 100 dB
Euphausiids	- 80 dB
Amphipods	- 80 dB
Siphonophores	- 67 dB

The calculated S_v values are not that different from the S_v obtained from the voltages (Table 2) for three of the tows. Therefore this was evidence that the scattering layers and the measured voltages were likely from the zooplankton caught in the nets.

When the copepods were included in the calculation of S_v using equation (2) for tow 11 the S_v was higher than the S_v calculated from the voltage. There were no *Calanus* in the sample and all the species of copepods were much smaller than the *Calanus* species. Therefore their target strength was likely much lower than -100 dB. When the copepods were excluded from the calculation and only the euphausiids were used the two S_v values were much closer. This suggests that the TS of -100 dB was too high for the small copepods.

Siphonophores were the dominant animals in sample 1 of tow 9 taken at 110 m. Therefore, it was assumed that they were the only significant sound scatterer. If this assumption is correct than it is possible to calculate their target strength at this depth from their density and the voltage of the echo. The TS was -71 dB, which is lower than that given for an estimate of siphonophore TS by Kaye (1978). But considering the uncertainties in both estimates they are surprisingly close. The value of -67 dB was used as a TS for

the siphonophores in the calculations in Table 2 because these animals were near the surface and larger than those in tow 9, and since the gas bubble would likely expand as the animals rose in the water it was assumed their TS would increase above -71 dB. Due to the wide volume range of the siphonophores (Fig. 4) estimating the TS was difficult.

Fish larvae length frequencies

The most abundant fish larvae was the silver hake, *Merluccius bilinearis*. Significant differences were found in the sizes of silver hake caught on the different stations (Fig. 5, Table 4). This size difference was not due to the different sampling times as evidenced by the large number of large larvae caught during both daylight and night time hours.

The largest number and smallest larvae were caught during tows, 9, 10 and 11. No Silver hake were collected in tow 4 and very few in tow 3. On tows 1, 2, 5 and 8 the larvae were larger than in tows 6, 9, 10 and 11. This suggests that these latter tows were near areas of silver hake spawning. The estimated hatching time for mackeral at 15°C is 4 to 5 days and it is assumed it would be similar for the silver hake. Therefore, the small larvae were likely only 4 or 5 days drift from the spawning site.

The length frequencies are given for other less abundant fish larvae species *Limanda ferruginea*, *Glyptocephalus cynoglossus* and *Urophycis chuss* (Table 5, Fig. 6).

DISCUSSION

The sounder demonstrated its value by locating regions of high biological activity and showing the exact depth at which the animals were concentrated. With this information it was possible to carry out a more rational and effective sampling procedure than would have been possible had we only sampled blindly on randomly picked stations. Unfortunately it was not possible to identify the type of organism causing the backscattering from the echograms except for single large fish which produce a characteristic large echo. But when scattering layers are seen the only way to identify the organisms responsible was with net sampling and a multiple opening and closing net is indispensible for this sampling. It is possible that with the use of multiple frequencies transducers in the future, we could separate different sizes of acoustic scatters.

Areas of high acoustic backscattering were associated with high concentrations of zooplankton and generally larger numbers of fish larvae. The regions with the highest numbers of copepods, tows 9, 10 and 11, also had the highest numbers of fish larvae.

ACKNOWLEDGEMENTS

The authors would like to express their sincere appreciation for the late L.O. Jaroszynski's very able technical assistance in collecting and sampling biological samples, and Mr. S. Paulowich and Mr. W.B. Fraser of the Marine Ecology Laboratory for their assistance in obtaining the acoustic data.

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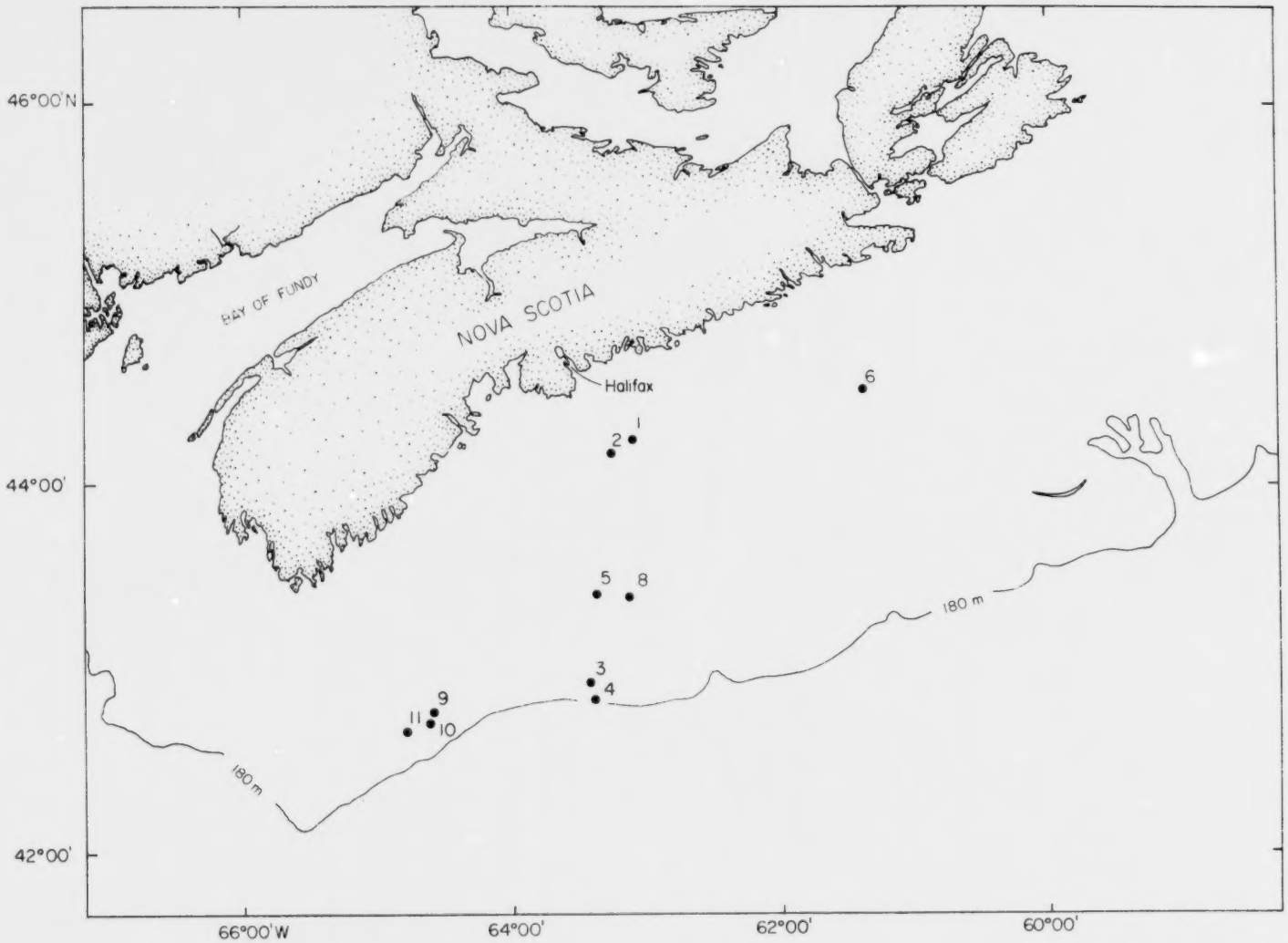


Fig. 1. Positions of the plankton tows on the Nova Scotia Shelf.

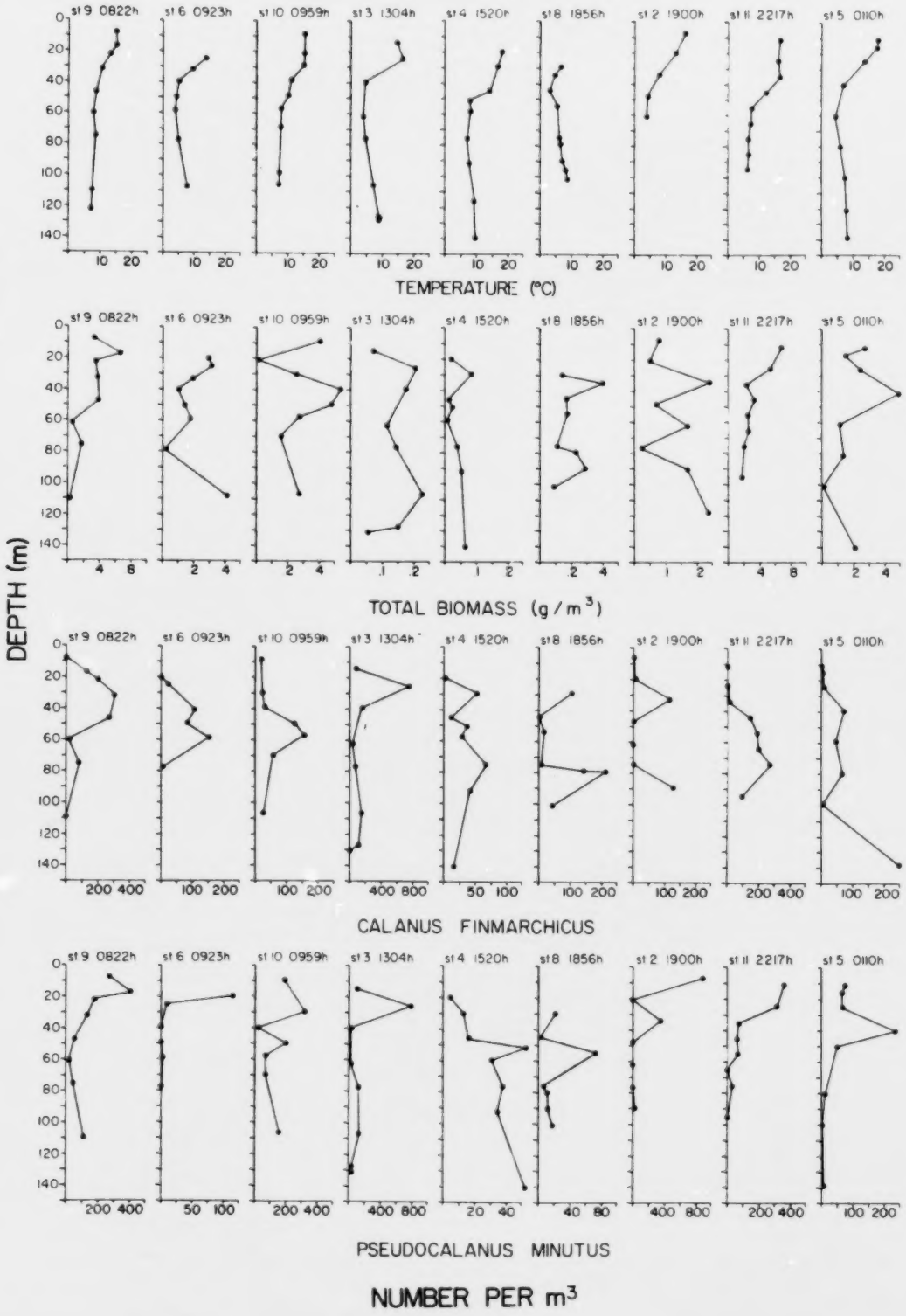
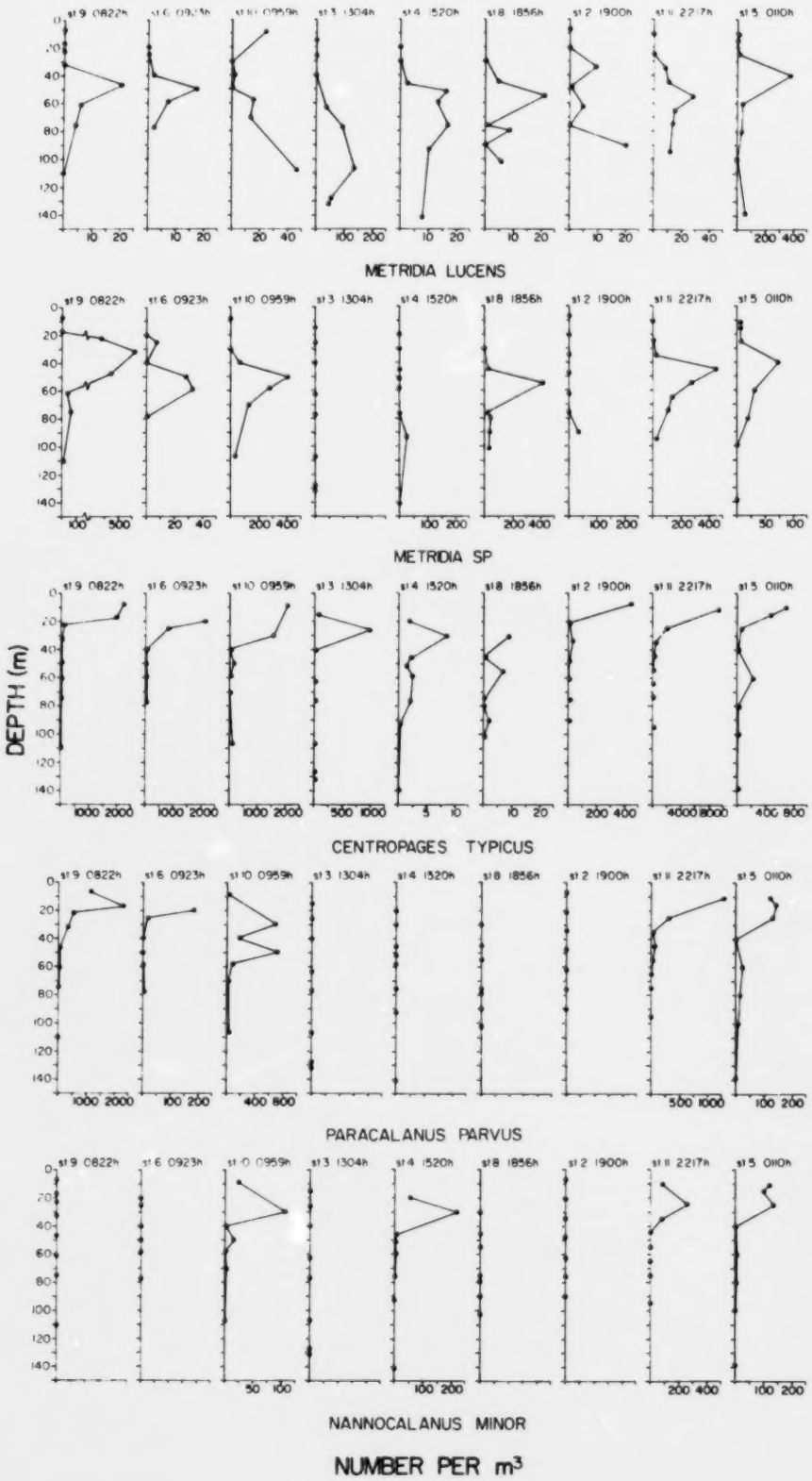


Fig. 2. Temperature and vertical distribution of zooplankton and fish larvae during the different tows and times.



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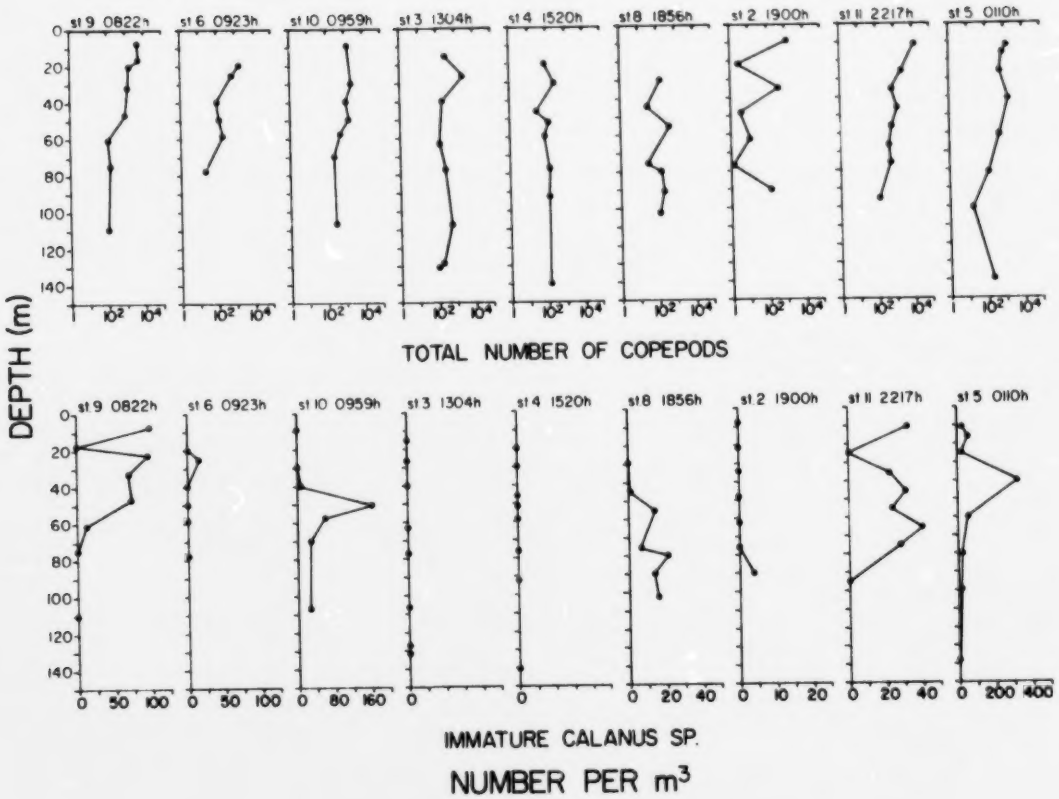

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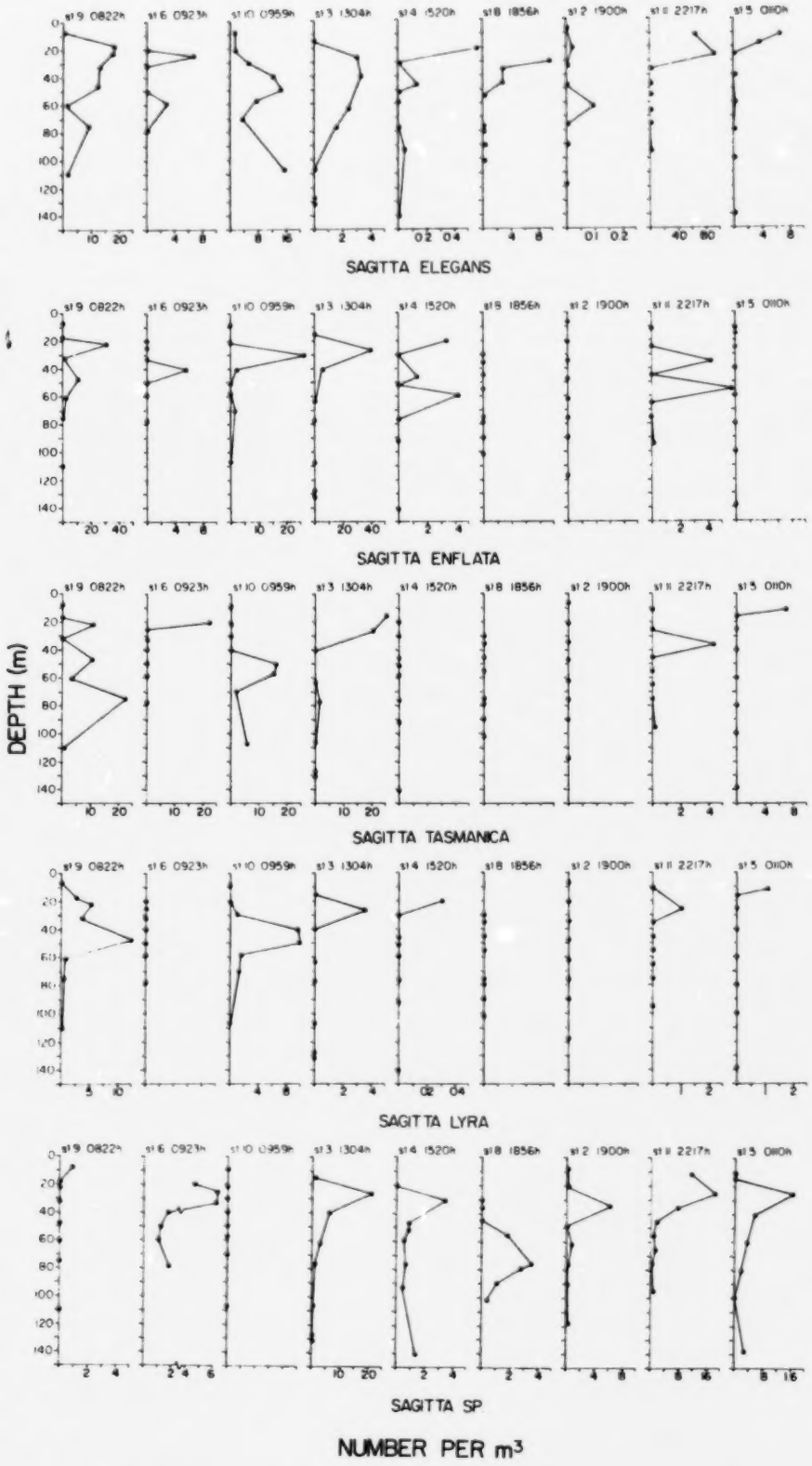

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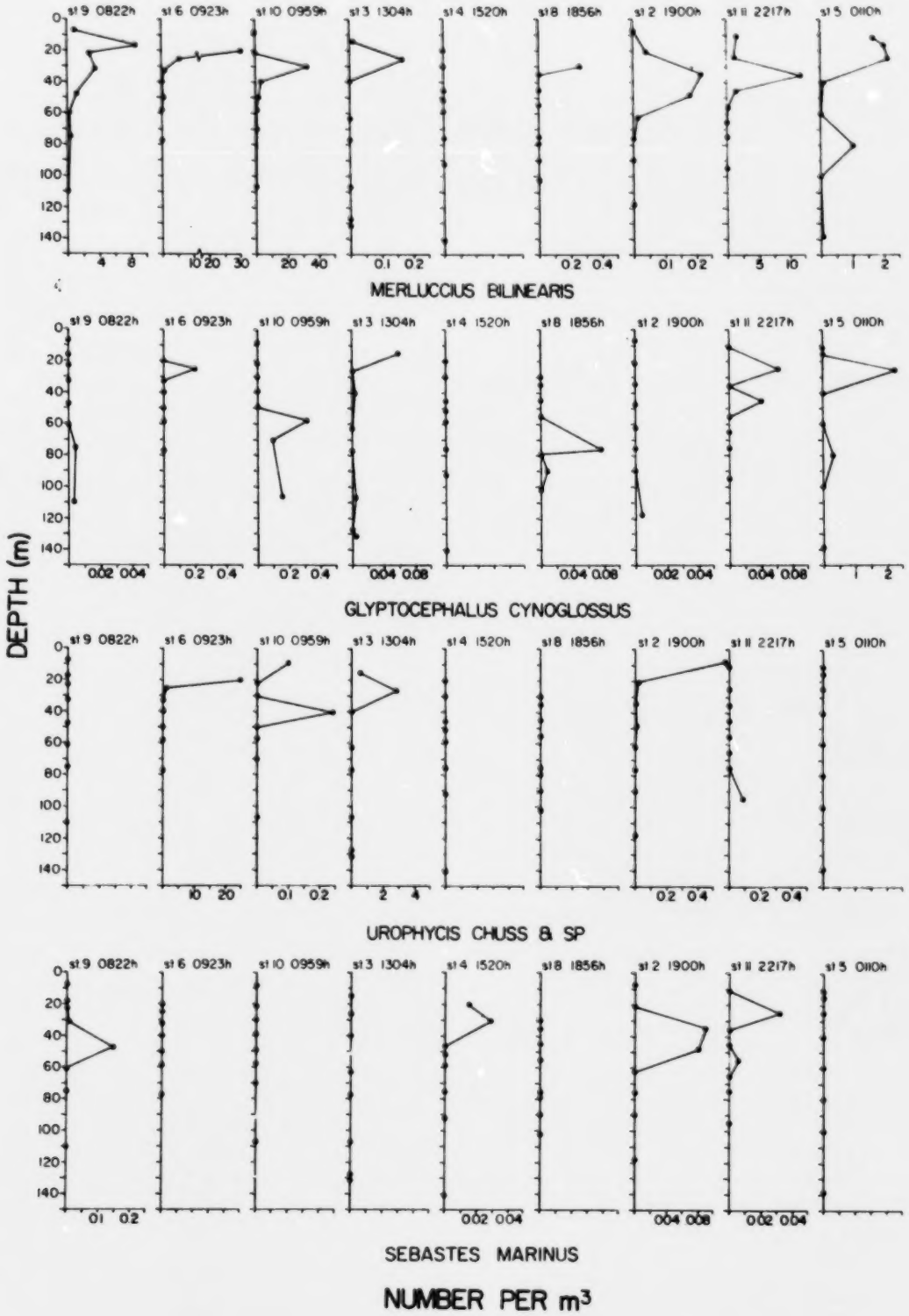

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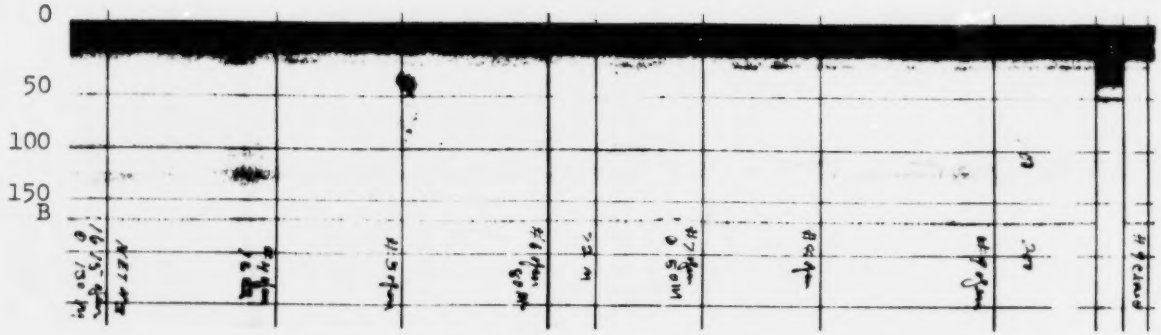
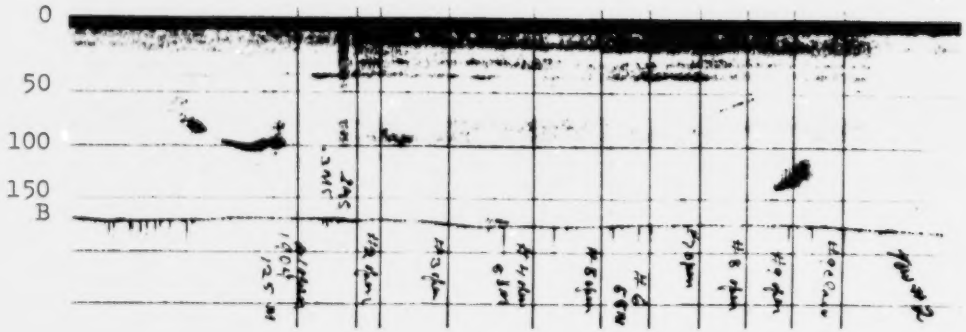
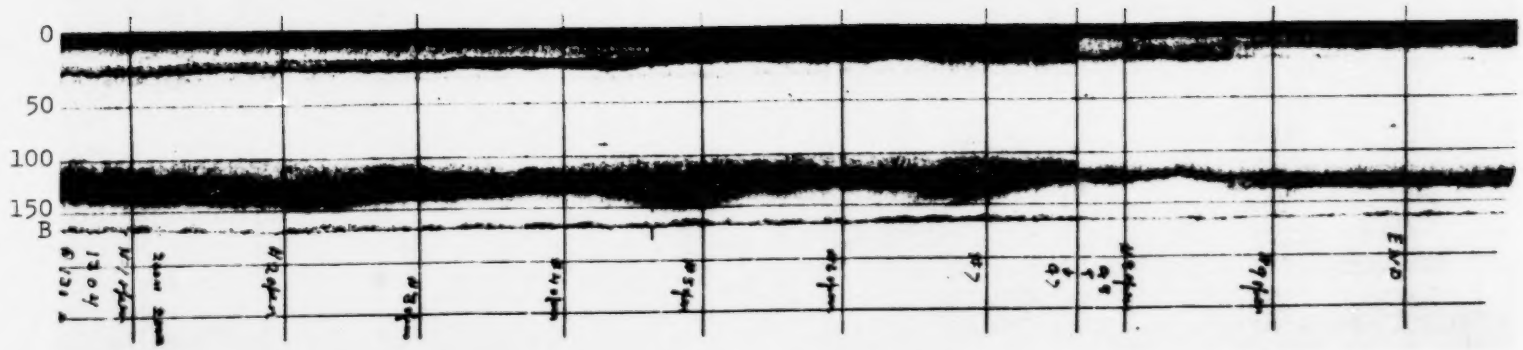


TOW 1



TOW 2

Fig. 3 Photographs of the echograms recorded during the time of each of the tows. The vertical lines represent the time each of the nets was closed. The distance between vertical lines 1; approximately 300 m. Depth is in meters on vertical axis; B - bottom.



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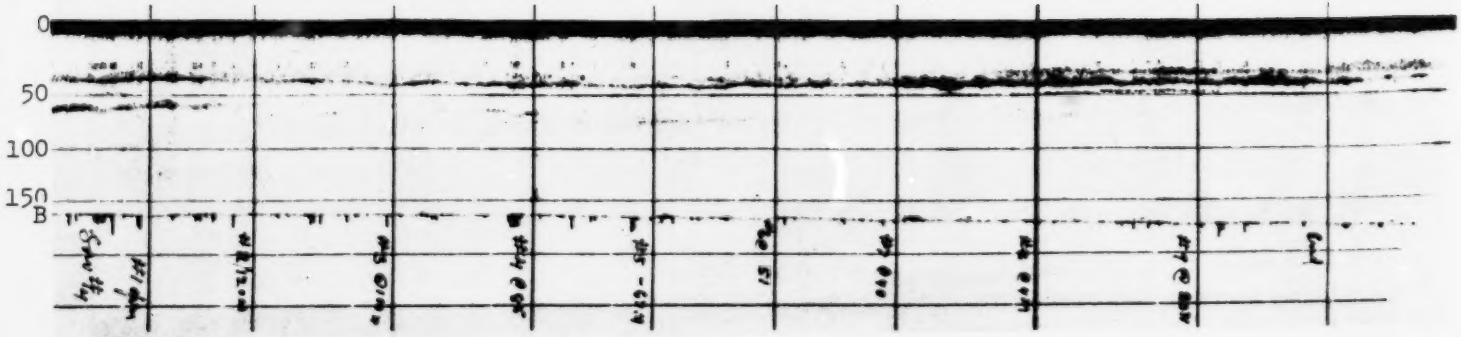

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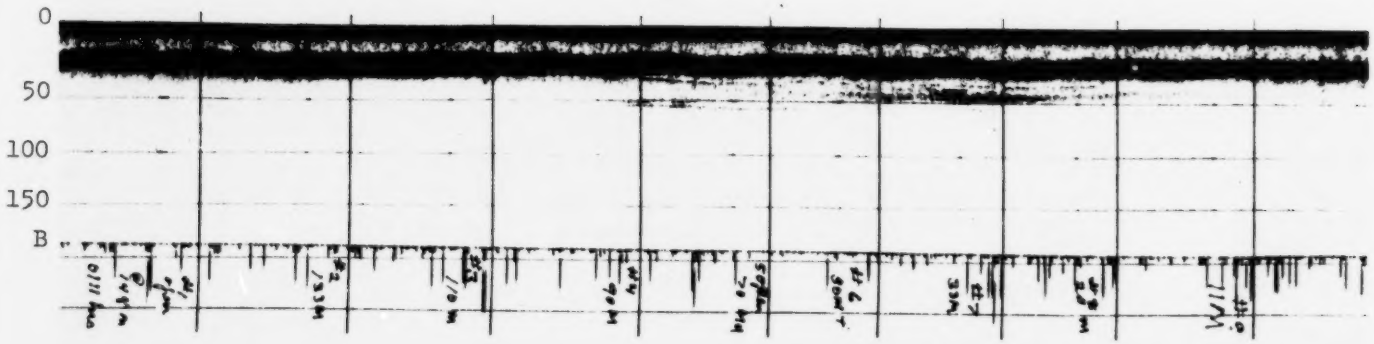

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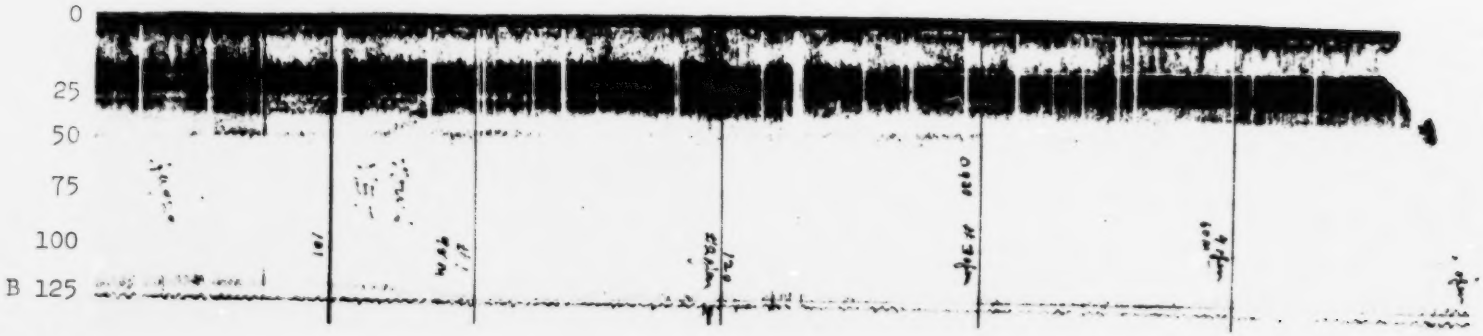

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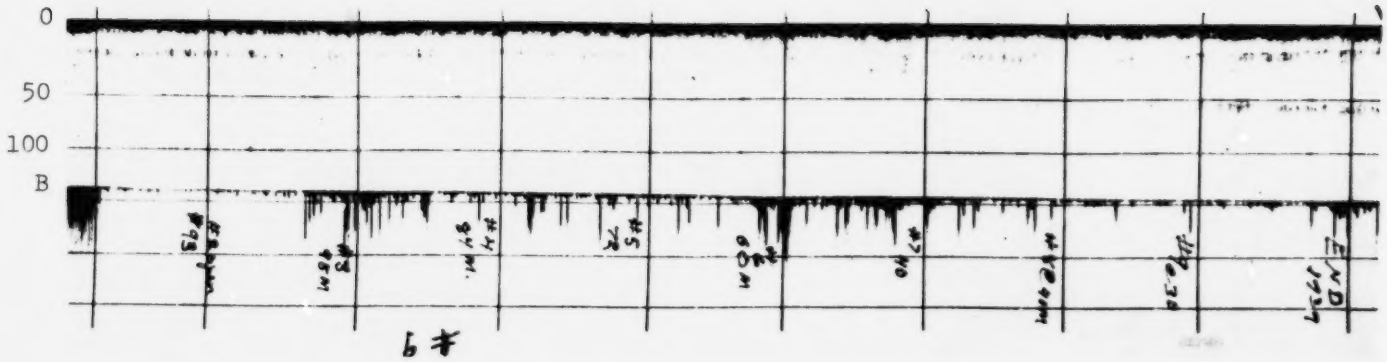

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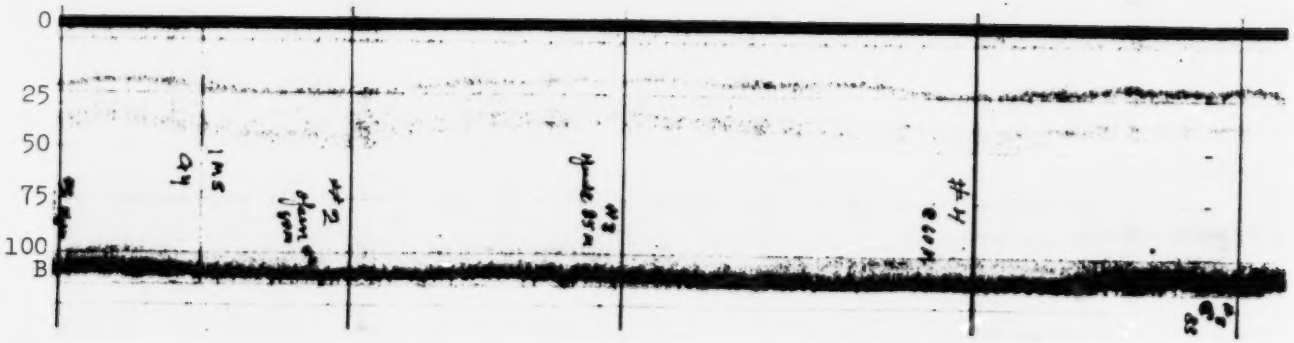

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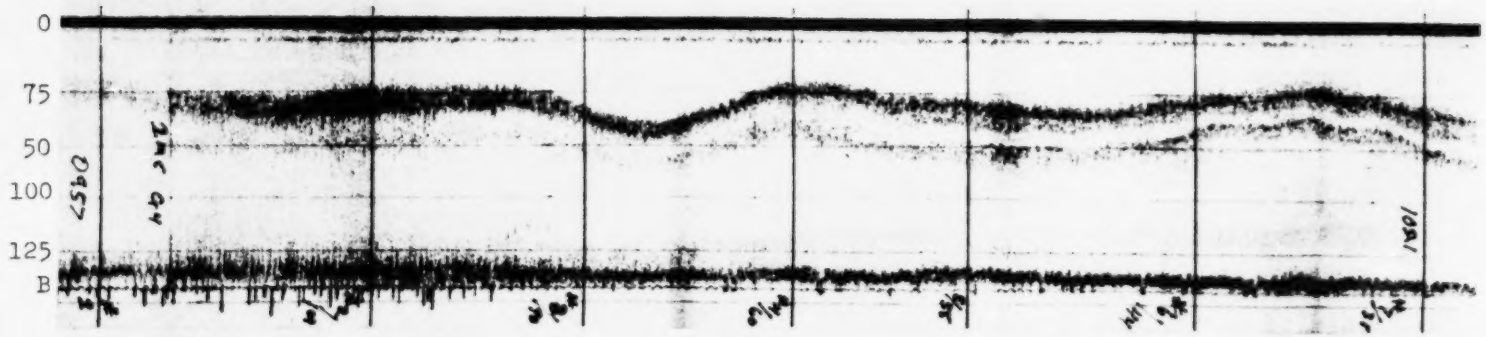

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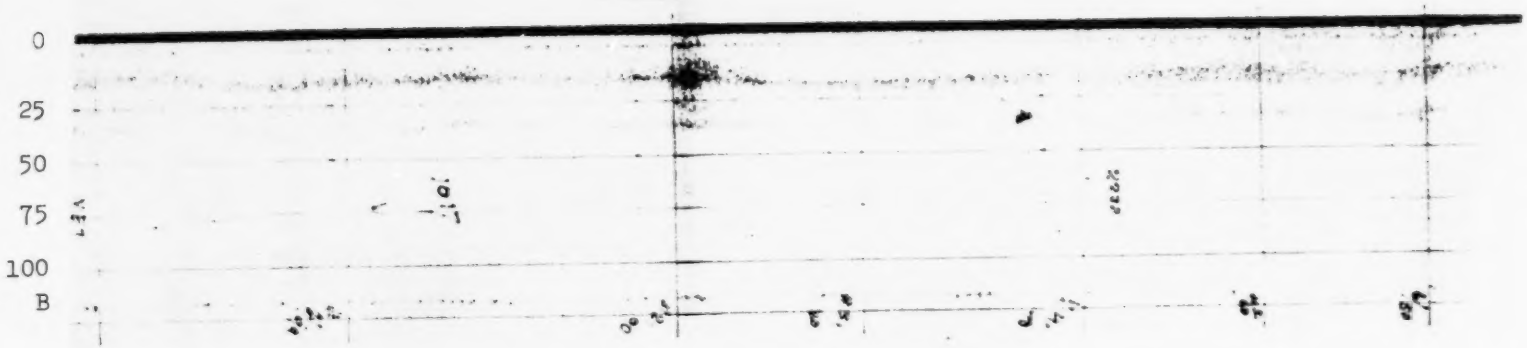

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Fig. 3 continued

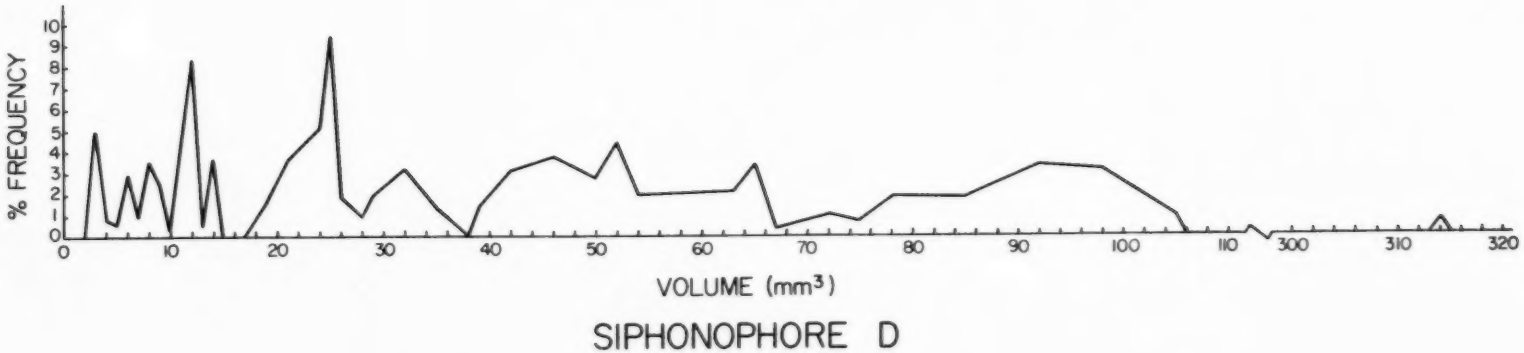

Fig. 4. Volume frequency distribution for siphonophores collected in all samples.

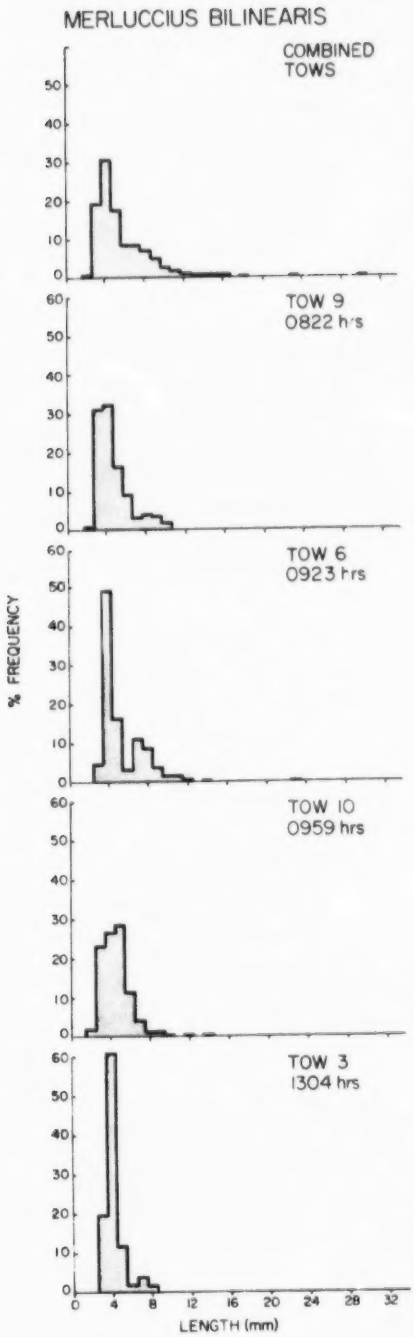

Fig. 5 Length frequency distribution of *Merluccius bilinearis* larvae collected in each tow, plus the frequencies for all tows combined. Each plot represents all the larvae collected in the nine nets.

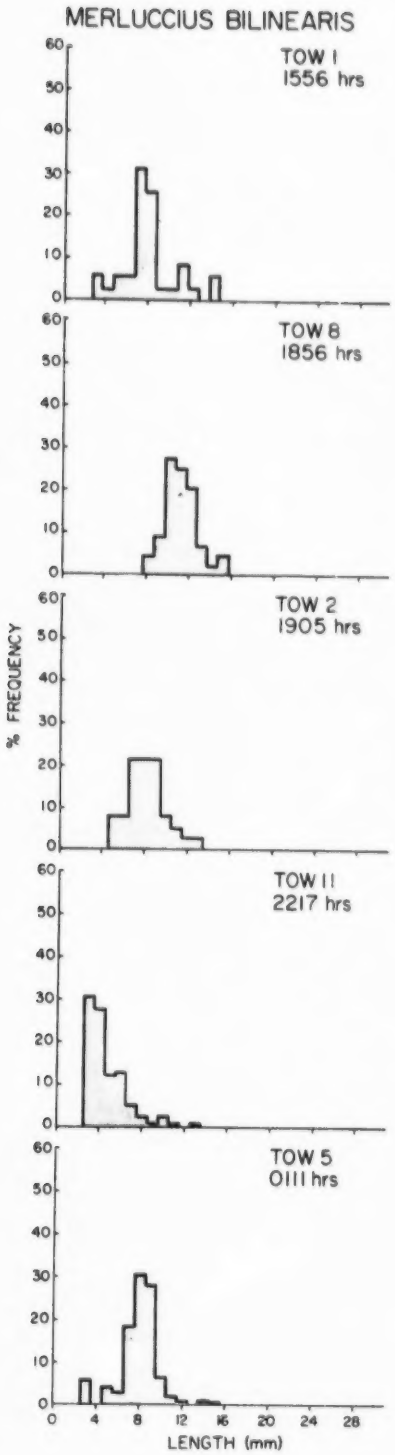

Fig. 5 continued

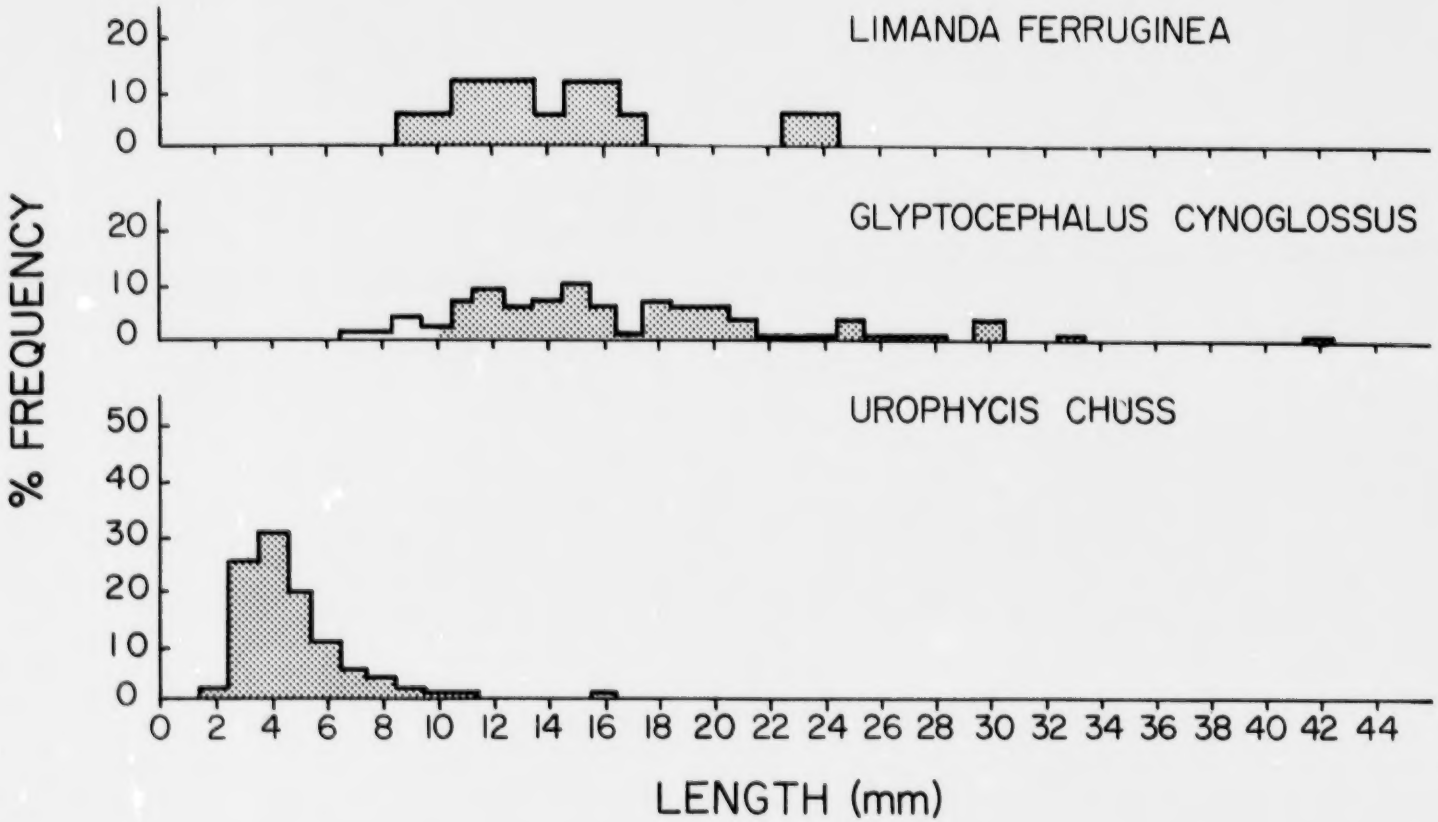

Fig. 6. Length frequency of Limanda ferrugina, Glyptocephalus cynoglossus and Urophycis chuss collected in all samples.

Table 1 Summary of animal contents expressed as number per m^3 of all samples taken during each tow along the depth, temperature, time and squared voltage of the acoustic echo from the scattering layers of animals at the different depths. The total sample biomass is expressed as g per m^3 and includes only animals less than 10 mm in length.

Table 1

ZOOPLANKTON DATA - SCOTIAN SHELF

DATE: August 27, 1976 LAT. 44°13'N LONG. 63°05'W

TOW 1

SAMPLE	1	2	3*	4*	5	6	7	8	9*
MESH	243	1050	243	1050	243	1050	243	1050	243
TIME	1556	1605	1618	1624	1629	1634	1640	1650	1655
DEPTH	146	146-0-146	130-132	120-105	105-80	80-50	48-40	40-30	30-14
VOLTAGE[2]	-	-	-	.087	.101	.005	.035	-	-
TEMPERATURE	9.5	-	9.2	8.8	6.4	2.4	2.0	4.6	14.0
AMPHIPODA									
Parathemisto abyssorum		.21				.12	2.91	2.31	
ASTEROIDEA									
Unidentified								.04	
CALANOIDA									
Aetideus armatus	2				1.31				
Calanus finmarchicus	213.24	.13			158.24	.07	34.0	.04	
Calanus hyperboreus	25	.10			1.74	.03			
Candacia armata					2.18	.36		.32	
Centropages typicus	5	.27			1.74	.16	1.94	.08	
Metridia longa					10.90	.06			
Metridia lucens	28				26.59		107.83	.04	
Pseudocalanus minutus	9.41	.96			56.23	.50	104.93	.24	
Rhincalanus nasutus						.02			
Temora longicornis	1.57					.02			
CARIDEA									
Unidentified		.010				.017			
CHAETOGNATHA									
Eukrohnia foveri						.02	.97		
Eukrohnia hamata		.002				.01		.005	
Sagitta elegans	.532	.004	.313		.054	.035	.642	.008	2.991
Sagitta sp.									
CLADOCERA									
Evadne spinifera		1.01				.41		.61	
CTENOPHORA								.003	
CYCLOPOIDA									
Oithona atlantica					3.05				
EUPHAUSIACEA									
Meganyctiphanes norvegica		.02						.41	
Thysanoessa longicaudata		.04				.03	.97		
Thysanoessa raschii								.04	
Thysanoessa sp.				.031		.127			
Unidentified	.048	.058	.156		.270	.01	.444	1.345	.431
HYDROZOA									
Aglantha digitale		.06			.44	.09			
Lensia conoidea					5.67	.14			
Obelia sp.						.02			
Siphonophore C								.508	
Siphonophore D		.172	.078	.121		.265			3.50
Siphonophore - unidentified					.324	.161			
Medusa D		.012							.02
Medusa				.007					

TOW 1

SAMPLE	1	2	3*	4*	5	6	7	8	9*
OSTEICHTHYES LARVAE									
Glyptocephalus cynoglossus		.007	.005				.035	.011	.00
Hippoglossoides platessoides				.003					
Limanda ferruginea							.025		
Merluccius bilinearis		.005				.003	.075	.011	.37
Tautogolabrus adsperus		.013							
Urophycis sp.		.002							
Urophycis chuss		.004						.050	.06
POLYCHAETA									
Tomopteris sp.	.097	.010	.235		.054	.006		.003	
Tomopteris helgolandica						.01			
TOTAL SAMPLE BIOMASS	.293	.008	.284	.003	.218	.013	.115	.023	.121

* Small Bugs Not Analyzed.

ZOOPLANKTON DATA - SCOTIAN SHELF

DATE: August 27, 1976 LAT. 44°9.6'N LONG. 63°15'W

TOW 2

SAMPLE	1*	2	3	4	5	6	7	8	9
MESH	243	1050	243	243	243	243	243	243	243
TIME	1905	1910	1913	1915	1917	1920	1921	1923	1925
DEPTH	125-111	111-97	97-83	83-69	69-55	55-41	41-27	27-14	14-0
VOLTAGE[2]	.017	.073	.113	.092	.012	.068	.225	.408	-
TEMPERATURE	-	-	-	-	4.4	4.6	8.2	13.8	16.8
AMPHIPODA									
Parathemisto abyssorum		.15		.17		2.22	2.38	2.10	27.61
ASTEROIDEA									
Unidentified								.15	
BRACHYURA									
Unidentified								.49	
CALANOIDA									
Aetideus armatus			1.86		.1				
Anomalocera opalus								.15	
Calanus finmarchicus		1.48	126.56	.31	2.0	1.17	118.93	.68	
Calanus hyperboreus		.19	3.72	.18	.06				
Calanus sp.[1]			3.72						
Candacia armata		.04		.10	.1	1.52		1.66	
Centropages typicus					.3	.47	26.16	.49	441.76
Euchirella rostrata		.04							
Metridia longa		.08		.03	.1				
Metridia lucens		.04	20.47		5.0	.23	9.51		
Metridia sp.			33.50						
Nannocalanus minor									9.20
Pseudocalanus minutus		.19	22.33	.21	11.0	.93	365.78	.20	892.72
Rhincalanus nasutus				.008					
Temora longicornis				.008			30.92	.34	285.30
Unidentified		.04		.02					
CARIDEA									
Pandalid								.10	
CHAETOGNATHA									
Eukrohnia fowveri							2.38		
Eukrohnia hamata		.04		.03	.05	.12			
Sagitta elegans					.1			.02	
Sagitta sp.	.173	.026		.043	.688		6.255	.046	.008
Unidentified								.05	
CLADOCERA									
Evadne spinifera		.11		.02			21.41	.10	368.13
Podon intermedius									73.63
CYCLOPOIDA									
Oithona atlantica			3.72	.02			4.76		
DECAPODA									
Unidentified shrimp						.122			

TOW 2

SAMPLE	1 *	2	3	4	5	6	7	8	9
EUPHAUSIACEA									
Meganyctiphanes norvegica				.05		1.28		.15	
Thysanoessa inermis				.027					
Thysanoessa longicaudata				.098					
Thysanoessa raschii						.12	4.76	.15	
Thysanoessa sp.	.173	.017							
Unidentified			.053	.008	.400	1.329	.145	.487	
GASTROPODA									
Clione sp.			.186	.027	.063				
Limacina helicina									9.20
Limacina retroversa				.008					
HYDROZOA									
Aglantha digitale		.19	3.72	.48	20.64	2.0	7.14	3.02	
Lensia conoidea		.72	5.58	.66	.12				
Siphonophore C		.325		1.823	.600			1.870	
Siphonophore D	.312	.479	.737	.716	.300			3.852	
Siphonophore colony								.009	
Siphonophore unidentified				.433	13.0		5.382		.128
Medusa D		.274	.263			16.489			
Medusa	.104								
OSTEICHTHYES LARVAE									
Glyptocephalus cynoglossus	.004								
Limanda ferruginea	.004							.01	
Merluccius bilinearis					.013	.181	.218	.039	
Pseudopleuronectes americanus								.009	
Sebastes marinus						.008	.009		
Tautogolabrus adsperus							.373	.193	
Urophycis chuss						.008			
Urophycis sp.								.02	.58
Unidentified								.009	
POLYCHAETA									
Tomopteris helgolandica		.009	.05		.063				
Tomopteris sp.	.139	.026	.211						.008
TOTAL SAMPLE WEIGHT/M3	.249	.058	.171	.018	.170	.063	.249	.048	.150

* Small Bugs Not Analysed

[1] Immature

ZOOPLANKTON DATA - SCOTIAN SHELF

DATE: August 28, 1976 LAT. 42°55'N LONG. 63°25'W

TOW 3

SAMPLE	1	2	3	4	5	6	7	8	9
MESH	243	1050	243	243	243	243	243	243	243
TIME	1304	1309	1314	1319	1324	1328	1334	1339	1344
DEPTH	131	125-130	128	107	77	63	40	26	15
VOLTAGE^2	-	-	-	-	-	-	.074	.818	-
TEMPERATURE	9.4	9.3	9.5	7.5	5.0	4.2	4.8	17.0	15.0
AMPHIPODA									
Parathemisto abyssorum		.02		1.76		.23	6.69	20.85	6.97
Phrosina semilunata									1.74
APPENDICULARIA									
Oikopleura sp.		.008							
BRACHYURA									
Unidentified	.64		.82						.11
CALANOIDA									
Acartia danae								20.85	5.22
Aetideus armatus			1.63						
Calanus finmarchicus	25.45	.02	119.27	160.22	81.88	42.74	167.34	771.51	90.55
Calanus hyperboreus	2.55	.39	1.63		1.57				
Candacia armata		.02						20.85	3.48
Candacia sp.							1.67		
Centropages typicus	1.27	.02		3.52	7.87	1.24	6.69	1167.69	76.62
Euchaeta sp.		.05							
Mecynocera clausi								62.55	10.45
Metridia longa			.82	3.52					
Metridia lucens	48.36	.04	53.92	137.33	97.63	36.55	1.67		
Nannocalanus minor						.62		521.29	3.48
Paracalanus parvus					1.76			417.03	52.24
Pleuromamma borealis	1.27								
Pseudocalanus minutus	38.82	.28	37.58	140.85	124.40	27.26	21.75	792.36	95.77
Temora longicornis		.008				2.48	1.67	83.41	3.48
CARIDEA									
Pandalid									.11
CHAETOGNATHA									
Sagitta elegans	.008				1.57	2.48	3.35	3.108	
Sagitta enflata							5.02	41.70	
Sagitta lyra								.561	
Sagitta sp.	.314	.029	.249	.454	.976	1.029	6.005		.648
Sagitta tasmanica					1.57			20.85	26.19
Sagitta unidentified	.008							20.85	
CIRRIPEDIA									
Unidentified		.008							
CLADOCERA									
Evadne spinifera	5.09	.02	.82				1.67	83.41	1.74
Podon sp.						1.24			
CRUSTACEA									
Squillidae sp.								.511	1.96
Palinura sp.								.003	

TOW 3

SAMPLE	1	2	3	4	5	6	7	8	9
CYCLOPOIDA									
Oithona atlantica					1.57		5.02		
Oithona similis	.64								
Oncaea venusta	.64								
EUPHAUSIACEA									
Thysanoessa longicaudata		.008					.21		
Thysanoessa sp.							1.67		.11
Thysanoessa unidentifiable							.21	20.85	
Euphausiid sp.		.004			.043		.088		
GASTROPODA									
Clione sp.				3.52	6.30	1.24	8.37		1.74
Limacina helicina				1.76		.62			1.74
Limacina retroversa			.82					20.85	
Unidentified			1.63						
HYDROZOA									
Ablyopsis sp.		.008							
Aglantha digitale	2.55	.03	.82	1.76	20.47	5.67			5.22
Lensia conoidea		.64							
Siphonophore C		.076							
Siphonophore D			.05		4.488		.658	.611	.394
Siphonophore - unidentified	.086	.116	.150	2.043		9.437			
MACRURA									
Thalassinidea unidentified		.18							
Unidentified	.08								
OSTEICHTHYES LARVAE									
Glyptocephalus cynoglossus	.004	.004		.004			.003		.056
Limanda ferruginea							.10		
Hippoglossoides platessoides							.047		
Tautogolabrus adsperus								1.351	.138
Urophycis chuss								.255	.254
Urophycis sp.								2.61	.22
Merluccius bilinearis								.170	.001
PENAEIDEA									
Sergestes sp.								2.61	
POLYCHAETA									
Tomopteris septentrionalis	1.27	.05							
Unidentified					1.57				
Tomopteris helgolandica				.156					
Tomopteris sp.	.229	.025							
STOMATOPODA									
Unidentified								2.61	.44
THALIACEA									
Thaliacea sp.								2.61	
TOTAL BIOMASS / M ^{3}	.055	.007	.151	.229	.145	.114	.175	.207	.072

ZOOPLANKTON DATA - SCOTIAN SHELF

DATE: August 28, 1976 LAT. 42°50.5 N LONG. 63°23'W

TOW 4

SAMPLE	1	2	3	4	5	6	7	8	9
MESH	243	1050	243	243	243	243	243	243	243
TIME	1521	1525	1530	1535	1539	1543	1548	1553	1558
DEPTH	146-135	135-100	100-85	85-68	67-51	51-52	52-40	40-20	20
VOLTAGE^2	.033	-	.013	.020	.015	.055	.511	.082	-
TEMPERATURE	10.0	9.6	8.0	7.2	8.2	8.0	14.5	17.0	18.4
AMPHIPODA									
Parathemisto abyssorum						.03	.09	.14	
Parathemisto sp.									.69
ANOMURA									
Pagurus sp.					.03				
APPENDICULARIA									
Oikopleura sp.								2.19	
ASTEROIDEA									
Unidentified				1.0					
BIVALVIA									
Mya sp.							.28		
BRACHYURA									
Unidentified				.03				.14	.13
CALANOIDA									
Acartia danae					.44	.50	.41	32.80	12.35
Acartia sp.				1.0					
Aetideus armatus			1.70	1.0					
Calanus finmarchicus	15.95	19.84	41.65	69.28	28.38	37.80	11.30	54.66	1.03
Calanus hyperboreus		.84	.42	.03					
Calocalanus parvus							.28		.34
Candacia armata					.44		.14		
Centropages bradyi							.28	28.42	11.32
Centropages hamatus						1.01			
Centropages typicus		.42	.42	2.01	2.62	1.51	2.21	8.75	2.06
Clausocalanus sp.		6.33							
Euchaeta sp.		.42							
Mecynocera clausi				2.01			.28		.69
Metridia longa					3.06	1.01	1.24		
Metridia lucens	7.98	.84	10.20	17.07	13.10	16.63	2.07		
Metridia sp.			24.65						
Nannocalanus minor					.44		.83	220.84	52.50
Paracalanus parvus					.44				
Pleuromamma borealis	74.69	.42						.14	
Pseudocalanus minutus	52.21	8.87	34.42	38.15	30.57	52.92	16.27	13.12	4.46
Rhincalanus nasutus		.84							
Temora longicornis							.14		
Temora styliforma									.34
Tortanus discaudatus						.50			
Unidentifiable					1.31				
CARIDEA									
Pandalid						.50			
Unidentifiable		.84							

TOW 4

SAMPLE	1	2	3	4	5	6	7	8	9
CHAETOGNATHA									
Sagitta elegans		.009					.14		.566
Sagitta enflata					.44		.14		.34
Sagitta lyra		.003							.031
Sagitta sp.	.139		.042	.065	.054	.089	.087	.353	
Chaetognatha unidentifiable	.73						.14	.14	.34
CIRRIPEDIA									
Unidentified	.73								
CLADOCERA									
Evadne spinifera	.73	.42	.42				.14	2.19	
Podon intermedius					.44	1.01			
CRUSTACEA									
Larval shrimp						.006			
Lucifer sp.				.008					
Squillidae sp.					.027		.004		.015
CYCLOPOIDA									
Corycaeus speciosus			.42					2.19	
Corycaeus sp.							.14		.34
Faranula carinata								2.19	
Oithona atlantica		.42	1.70	4.02		4.54	1.10	2.19	.34
EUPHAUSIACEA									
Meganyctiphanes norvegica	.73								
Thysanoessa inermis			.85	2.01					
Thysanoessa longicaudata							.009		.04
Thysanoessa sp.		2.96			.87	1.016	1.10		1.792
Thysanoessa unidentified		.42		2.24					.04
GASTROPODA									
Clione sp.	7.25	.42		2.01	1.31	1.01	.97		
Limacina helicina		.84			.44		1.93	8.75	.34
Unidentified							.14	2.19	
HYDROZOA									
Aglantha digitale				1.0		1.01	.55		
Unidentifiable		.42							
Siphonophore D	.081	.100		.161			.638	.059	.107
Siphonophore unidentified			.157			.446	.004		
HYDROZOA									
Medusa		.003				.006			.020
Medusa C			.003						
MACRURA									
Thalassinidea unidentified		.42							
Unidentified								.14	
OSTEICHTHYES LARVAE									
Platophrys grohmanni			.003						
Sebastes marinus								.029	.015
Species 1			.003						
Syngnathidae		.003							
POLYCHAETA									
Tomopteris septentrionalis			.42						
Tomopteris sp.			.008	.008					
Unidentified								.14	
PORIFERA									
Unidentifiable			.05	.03			.009		

TOW 4

SAMPLE	1	2	3	4	5	6	7	8	9
STOMATOPODA									
Unidentified					.03				
UROCHORDATA									
Salps D			.021			.019			
TOTAL BIOMASS/M^3	.062	.003	.050	.039	.005	.022	.009	.085	.019

ZOOPLANKTON DATA - SCOTIAN SHELF

DATE: August 29, 1976 LAT. 43°24'N LONG. 63°21'W

TOW 5

SAMPLE	1	2	3	4	5	6	7	8**	9
MESH	243	1050	243	243	243	243	243	243	243
TIME	0111	0117	0122	0127	0131	0135	0139	0144	0149
DEPTH	148-130	132-110	110-90	90-70	70-50	50-30	30-20	20-11	11
VOLTAGE[2]	-	-	-	-	.075	.496	3.410	.607	.734
TEMPERATURE	9.0	8.6	8.1	6.8	5.0	7.5	14.2	18.4	18.4
AMPHIPODA									
Hyperia galba									
Hyperoche medusarum		.004							
Parathemisto abyssorum		.002							
Parathemisto gaudichaudi	.28	.01	.007	.13					
Unidentified gammarid		.007							
		.002	.003						
APPENDICULARIA									
Oikopleura sp.		.007	.22					7.00	15.0
ASTEROIDEA									
Unidentified				1.04					
BRACHYURA									
Unidentified		.004							
CALANOIDA									
Acartia danae		.03			2.00		11.04		
Calanus finmarchicus	247.53	.19	.67	64.78	43.00	70.00	2.21		
Calanus hyperboreus	13.38	.14		1.04	2.00				
Calanus sp.[1]		.06	8.90	18.81	50.00	327.00	19.87	52.00	22.0
Calocalanus parvus			.22				6.62	7.00	15.0
Candacia armata		.007			28.0	60.00	11.04	22.00	15.0
Candacia sp.			.67						7.0
Centropages bradyi									
Centropages typicus		.03	4.67	15.67	218.0	7.0	55.21	476.0	655.0
Mecynocera clausi					3.0		22.08	7.0	
Metridia longa	6.69	.04			30.0	89.0	30.92		
Metridia lucens	55.57			20.90	40.0	379.0	4.42		7.0
Metridia sp.			.67	18.81	30.0	74.0	6.62	7.0	7.0
Nannocalanus minor				2.09	2.00		136.91	96.0	119.0
Paracalanus parvus		.12	7.12	14.63	24.0		130.29	141.0	119.0
Pleuromamma robusta		.007							
Pseudocalanus minutus	6.69	.03	3.78	10.45	51.00	238.0	66.25	67.0	75.0
Rhincalanus nasutus		.004							
Unidentified		.004							
CARIDEA									
Pandalus montagui				.012					
CHAETOGNATHA									
Eukrohnia hamata		.04							
Sagitta elegans								7.0	
Sagitta lyra					.2				6.556
Sagitta tasmanica		.004							1.083
Sagitta sp.	.275	.029		.188	.359	.552	1.622		7.0
Unidentified		.014		1.04	.2				

TOW 5

SAMPLE	1	2	3	4	5	6	7	8 **	9
CLADOCERA									
Evadne nordmanni			.22		.2		35.33		15.0
Evadne spinifera		.007	.22					14.0	29.0
Evadne sp.							4.42		
Podon intermedius		.004							
CTENOPHORA									
Unidentifiable		.014			.098				
CYCLOPOIDA									
Oithona atlantica		.02	1.34	1.04	3.00	30.00			
Oithona venusta							7.00		
DECAPODA									
Unidentified larvae shrimp							.324		
EUPHAUSIACEA									
Meganyctiphanes norvegica		.01			.2		2.21		
Thysanoessa gregaria									14.00
Thysanoessa inermis						2.00			
Thysanoessa longicaudata		.01						14.00	7.00
Thysanoessa raschii		.007					2.21		
Thysanoessa sp.	.017			1.04	3.327	.473	3.291	7.0	14.782
Unidentified		.04		.157				7.0	7.0
GASTROPODA									
Clione sp.	2.23	.004		.031		.158	4.528		
Limacina helicina						7.0	6.62		7.0
Limacina retroversa						7.0			
HYDROZOA									
Agantha digitale		.01					8.83		
Lensia concidea		.20		2.09	2.0	2.0			
Leuckartiara sp.		.002							
Siphonophore D	.034	.009			.131	.236	7.135		
Siphonophore unidentified				.063					9.143
Medusa D	.034								
OSTEICHTHYES LARVAE									
Enchecyopus cimbrius	.28						.108		.004
Glyptocephalus cynoglossus				.031			2.321		
Merluccius bilinearis	.002	.002		1.044		.039	2.162	2.0	1.666
Tautogolabrus adsperus					.004				
PENAEIDEA									
Lucifer sp.								.2	
POLYCHAETA									
Tomopteris septentrionalis		.004							
Tomopteris sp.		.002			.163	.118	.541		.301
Unidentified									7.00
THALIACEA									
Thalia democratica		.01						22.0	7.0
Thalia sp.							2.21		30.0
Salps-unidentified C		.107				.079			
Salps-unidentified D		.008							
Salps-unidentified					.094				
TOTAL BIOMASS/M3	.212	.005	.004	.132	.102	.481	.231	.133	.259

** Large Bugs Not Counted
! Immature

ZOOPLANKTON DATA - SCOTIAN SHELF

DATE: August 30, 1976 LAT. 44°29'N LONG. 61°21'W

TOW 6

SAMPLE	1**	2	3	4	5	6	7 *	8	9
MESH	243	1050	243	243	243	243	243	243	243
TIME	0923	0928	0932	0937	0942	0949	0954	0958	1003
DEPTH	98-118	120-96	96-60	63-55	55-45	45-35	35-30	30-20	20
VOLTAGE[2]	.013	.012	.002	-	.035	.301	3.098	4.257	-
TEMPERATURE	7.8	7.9	5.0	4.1	4.6	5.6	10.0	14.4	-
AMPHIPODA									
Parathemisto abyssorum		.02	.2	11.0	4.16	2.31			
Parathemisto gaudichaudi		.02							
Parathemisto sp.								7.0	22.86
Unidentified hyperiid					.697				
ANOMURA									
Pagurus sp.		.028							
BRACHYURA									
Unidentified		.008							
CALANOIDA									
Calanus finmarchicus		.04	7.0	156.0	82.17	114.21		26.0	
Calanus hyperboreus		.09		7.0	2.08	1.73			
Calanus sp.[1]								14.0	
Candacia armata			.2		2.68	3.46		14.0	22.86
Centropages typicus		.98	21.0	41.0	7.28	4.04		834.0	2194.86
Metridia longa			.7	93.0	45.76				
Metridia lucens		.008	2.0	7.0	17.68	1.73			
Metridia sp.			.7	33.0	28.08			7.0	
Nannocalanus minor									22.86
Paracalanus parvus		.13	2.6					14.0	182.9
Pleuromamma robusta		.008							
Pseudocalanus minutus		.04	.5	2.0				7.0	114.32
Scolecithricella minor				2.0	1.04				
Temora longicornis		.02	.7	2.0		.58		7.0	68.59
CARIDEA									
Pandalid		.03			1.04				
CHAETOGNATHIA									
Eukrohnia hamata						.58			
Eukrohnia sp.		.02							
Sagitta elegans		.008	.23	3.0				7.0	
Sagitta enflata						.58			
Sagitta tasmanica		.008							22.86
Sagitta sp.		.028	.178	1.013	1.255	1.702	6.237	6.301	4.716
CLADOCERA									
Evadne spinifera		.03							
Evadne sp.		.02							
CYCLOPOIDA									
Oithona atlantica					.13				
DECAPODA									
Larval shrimp		.039		.084	.035	.054			

TOW 6

SAMPLE	1 **	2	3	4	5	6	7 *	8	9
EUPHAUSIACEA									
Thysanoessa raschii		.008							
Unidentified		.008	.029	.760	1.702	1.028	.597	.332	
GASTROPODA									
Clione sp.		.014	.46	7.0					22.86
Limacina helicina									22.86
Unidentified			.23						
HYDROZOA									
Dimophyes arctica		.008							
Diphyes dispar		.008							
Lensia conoidea		.40							
Rathkea octopunctata		.02							
Siphonophore unidentified		.568							
ISOPODA									
Microniscid larvae			.1						
OSTEICHTHYES LARVAE									
Gadid			.01			.58			
Glyptocephalus cynoglossus								.2	
Merluccius bilinearis		.004			.13	.036	.759	6.082	30.607
Urophycis sp.								.2	22.86
Urophycis chuss			.007					.497	1.684
Unidentified larvae			.011						
TOTAL BIOMASS/M3	.414	.010	.018	.188	.143	.100	.196	.321	.298

* Small bugs not counted

** No sample recovered

1 Immature

ZOOPLANKTON DATA - SCOTIAN SHELF

DATE: 31 August 1976 LAT. 42°23'N LONG. 63°07'W

TOW 8

SAMPLE	1	2 **	3	4	5	6	7	8*	9
MESH	243	1050	243	243	243	243	243	243	243
TIME	1856	1900	1905	1910	1915	1920	1925	1930	1935
DEPTH	122-93	19-100	95-85	84-75	72-60	60-50	50-40	40-30	30
VOLTAGE[2]	-	-	-	-	-	-	-	-	-
TEMPERATURE	9.2	8.8	7.8	6.8	6.5	6.0	3.6	5.0	7.0
AMPHIPODA									
Hyperia galba		.02							
Parathemisto abyssorum					.19				1.02
Unidentified				1.44		.89			
ANOMURA									
Pagurus sp.		.03							
BIVALVIA									
Mytilus sp.					.19				
CALANOIDA									
Acartia sp.									2.03
Aetideus armatus					.38				
Calanus finmarchicus	43.72	.04	214.18	145.14	8.35	16.5	1.98		108.78
Calanus hyperboreus		.01				2.36			
Calanus sp.[1]	15.51	.07	13.39	21.56	6.07	14.14	.85		
Candacia armata	1.41	.05	1.67	1.44					11.18
Candacia sp.						2.36			31.52
Centropages typicus		.01	1.67			7.07			9.15
Metridia longa	11.28	.01	15.06	1.44	1.33	66.0	7.36		3.05
Metridia lucens	5.64			8.62	.95	21.22	4.46		
Metridia sp.	36.66	.04	36.81	37.36	10.82	414.87	15.58		2.03
Nannocalanus minor		.05							
Paracalanus parvus			6.69		.76	7.07			3.05
Pleuromamma borealis	2.82								
Pleuromamma robusta	1.41								
Pseudocalanus minutus	16.92	.04	11.71	10.06	6.07	73.07	3.68		22.37
CARIDEA									
Pandalid		.01							
CHAETOGNATHA									
Eukrohnia foweri		.01							
Eukrohnia humata	1.41		1.67	1.44	.19	4.71			11.18
Sagitta elegans							2.950	2.903	9.72
Sagitta sp.	.378		.976	2.857	3.539	1.811			
Unidentified					.19				
CLADOCERA									
Evadne sp.	1.41								
CTENOPHORA									
Unidentified				.048					

TOW 8

SAMPLE	1	2**	3	4	5	6	7	8 *	9
CYCLOPOIDA									
Oithona atlantica					.38	4.71			
DECAPODA									
Unidentified shrimp								.065	
EUPHAUSIACEA									
Meganyctiphanes norvegica									2.03
Thysaneossa inermis							.04		
Thysaneossa sp.						2.398	1.118	0.065	2.862
Unidentified		.04							
GASTROPODA									
Clione sp.			1.67	1.44	.57	9.43	.85		8.13
Limacina helicina									1.02
Unidentified							.28		
HYDROZOA									
Aglantha digitale	1.41					2.36	1.13		
Halopsis ocellata						.29			
Lensia conoidea		1.34	1.05	17.25	1.52	2.36			
Siphonophore C					.371	.604			
Siphonophore D			.705	1.00	1.484	.906	1.520		
Medusa	.047	.163			.009	2.415			
Unidentified						2.36			
ISOPODA									
Microniscid larvae									2.03
MACRURA									
Unidentified		.02							
OSTEICHTHYES LARVAE									
Glyptocephalus cynoglossus			.007		.087				
Limanda ferruginea									.064
Merluccius bilinearis									.285
POLYCHAETA									
Tomopteris helgolandica				.048	.02				
Tomopteris sp.	.236								
Unidentified		.01							
TOTAL BIOMASS/M^3	.092	.012	.291	.229	.106	.172	.166	.403	.138

* Small bugs not counted
** Large bugs not counted

[1] Immature

ZOOPLANKTON DATA - SCOTIAN SHELF

DATE: September 1, 1976 LAT. 42°44.5 N LONG. 64°35.5 W

TOW 9

SAMPLE	1	2 **	3	4	5	6	7	8	9
MESH	243	1050	243	243	243	243	243	243	243
TIME	0822	0827	0832	0838	0843	0848	0853	0858	0903
DEPTH	110	110-85	85-65	65-54	54-40	39-25	25-20	20-15	15-0
VOLTAGE[2]	.753	.193	.070	.067	.118	.141	.289	-	-
TEMPERATURE	7.5	7.2	8.6	8.0	9.0	11.0	13.8	15.6	15.6
AMPHIPODA									
Parathemisto abyssorum	1.56	3.0	6.5		83.96				
Unidentified			2.17						
ASTEROIDEA									
Unidentified							10.74		
BRACHYURA									
Unidentified		.06	2.17		.66				101.4
CALANOIDA									
Acartia danae					20.99		10.74		67.6
Anomalocera opalus				1.0					
Calanus finmarchicus	7.0	.14	88.79	22.0	283.38	313.39	204.09	137.63	
Calanus hyperboreus		.03							
Calanus sp.[1]		.08		12.0	73.47	70.77	96.67		101.4
Calocalanus parvus									67.6
Candacia armata	2.33		15.16	4.0	31.49	30.33			33.8
Candacia sp.			15.16						
Centropages bradyi									33.8
Centropages typicus	11.67	.8	21.66	39.0	20.99	50.55	236.32	3991.4	4423.76
Mecynocera clausi			2.17	1.0		10.11	10.74		
Metridia longa	.78				31.49	50.55	32.22		
Metridia lucens			4.33	6.0	20.99				
Metridia sp.	4.67		60.63	36.0	440.81	626.78	375.96		
Nanocalanus minor				2.0					169.01
Paracalanus parvus		.4		16.0	41.98	343.72	526.34	2339.79	1115.0
Pseudocalanus minutus	108.96		41.14	20.0	52.48	141.53	182.61	412.9	270.41
Rhincalanus nasutus							10.74		
CARIDEA									
Pandalid		.14							
CHAETOGNATHA									
Sagitta elegans	1.455		9.210	1.030	12.274	13.137	18.043	18.445	
Sagitta enflata				2.0	10.5		32.22		
Sagitta lyra	.104		.354	.485	12.274	3.537	5.191	2.502	
Sagitta tasmanica	.78		23.82	3.0	10.5		10.74		
Sagitta sp.						10.11			.818
Unidentified									
CLADOCERA									
Evadne nordmanni	.78		4.33				10.74		1238.7
Evadne sp.	.78								
CYCLOPOIDA									
Faranula carinata	2.33								
Oithona atlantica			2.17	7.0	10.5	202.19	612.27	67.6	
DECAPODA									
Shrimp larvae			.236		1.023				

TOW 9

SAMPLE	1	2**	3	4	5	6	7	8	9
EUPHAUSIACEA									
Euphausia krohnii							21.48		
Euphausiacea sp.			.354						
Meganyctiphanes norvegica		.23	4.33			10.11			33.80
Thysanoessa raschii		.17							
Thysanoessa sp.	.416		6.5	.9	.292	30.33	10.825		.040
Unidentified		.05	2.17						
GASTROPODA									
Clione sp.	10.12		264.19	31.0	262.39	80.87			
Crescis virgula					10.5				
Limacina helicina								68.82	
HYDROZOA [1]									
Aglantha digitale		.08							
Lensia conoidea	.78	.06							
Siphonophore C	25.766								
Siphonophore D			.354						
Siphonophore unidentified	.78	.06	2.17						
ISOPODA									
Unidentified								68.82	
OSTEICHTHYES LARVAE									
Enchecyopus cimbrius							.005		
Glyptocephalus cynoglossus	.003		.004						
Hippoglossoides platessoides						.003		.004	
Merluccius bilineraris			.27	.152	1.098	3.496	2.787	8.948	.818
Myoxocephalus			.004						
Pseudopleuronectes americanus									
Sebastes marinus					.146	.003			
Unidentified								.004	
Species A-1							.085		
POLYCHAETA									
Tomopteris helgolandica	3.11		2.17						
Tomopteris septentrionalis		.03							
Unidentified		.32							
Tomopteris sp.	7.274			.030					
TOTAL BIOMASS / M^3	.096	.018	.176	.047	.390	.375	.351	.669	.337

** Large Bugs not analysed.

[1] Immature

ZOOPLANKTON DATA - SCOTIAN SHELF

DATE: September 1, 1976 LAT. 42°43'5N LONG. 64°36'n

TOW 10

SAMPLE	1	2 **	3	4	5	6	7	8 *	9
MESH	243	1050	243	243	243	243	243	243	243
TIME	0959	1004	1007	1010	1014	1018	1022	1026	1030
DEPTH	105-109	109-90	80-60	60-55	55-41	44-35	35-25	25-18	18-0
VOLTAGE[2]	.422	.210	.066	.181	.230	.290	.227	.006	.158
TEMPERATURE	7.4	7.5	8.0	8.0	10.5	11.2	15.2	15.6	15.7
AMPHIPODA									
Parathemisto abyssorum	11.45	.5	3.31						
Parathemisto sp.									23.75
Unidentified			1.65			2.0			
APPENDICULARIA									
Oikopleura sp.						2.0	26.8		
CALANOIDA									
Acartia sp.							26.8		
Aetideus armatus	5.73								
Calanus finmarchicus	28.63	.007	59.56	159.26	129.72	32.0	26.8		23.75
Calanus sp.[1]	25.76		28.13	46.24	162.15	7.0			
Candacia armata		.3	8.27	30.82		2.0			
Candacia pachydactyla					16.22				
Centropages bradyi	2.86						80.4		
Centropages typicus	117.37	.22	14.89	46.24	162.15	20.0	1581.11		2066.3
Euchaeta marina		.007							
Euchaeta sp.		.007							
Mecynocera clausi					81.08	4.0	53.6		
Metridia longa	17.18			35.96	32.43	7.0			
Metridia lucens	45.8		13.24	15.41		2.0			23.75
Metridia sp.	37.21		127.4	277.42	405.38	54.0			
Nannocalanus minor			1.65		16.22	2.0	107.19		23.75
Paracalanus parvus	34.35	.09	19.85	71.92	729.68	151.0	696.76		17.81
Pseudocalanus minutus	154.58	.03	64.53	66.79	194.58	20.0	321.58		190.01
Unidentified							26.28		
CARIDEA									
Pandalid		.04		.32					
CHAETOGNATHA									
Eukrohnia hamata							53.60		
Sagitta elegans	15.695		3.586	7.489	15.028	12.606	5.164	1.535	1.462
Sagitta enflata		.02	1.65			2.0	26.8		
Sagitta lyra			1.195	1.362	9.846	9.455	.951		
Sagitta tasmanica	5.73	.007	1.65	15.41	16.22				
Unidentified	2.86								
CLADOCERA									
Evadne nordmanni						9.0	80.4		
Evadne spinifera						2.0			47.5
Evadne sp.		.007		5.14	81.08				
CTENOPHORA									
Unidentified								.004	
CYCLOPOIDA									
Faranula carinata		.007							
Oithona atlantica	20.04		24.82	41.10	762.11	50.0	53.60		
Oncaea venustra							53.6		

TOW 10

SAMPLE	1	2**	3	4	5	6	7	8 *	9
DECAPODA									
Unidentified shrimp			.092						
Squillidae sp.						.083			
EUPHAUSIACEA									
Euphausia krohnii							26.8		
Euphausia sp.							26.8		
Meganyctiphanes norvegica		.14	1.65						
Thysanoessa raschii		.007							
Thysanoessa sp.	2.86		4.96	1.682	81.08	4.0		.026	.094
Unidentified		.014			.259				
GASTROPODA									
Clione sp.	17.18		142.29	164.40	4.0				
Limacina helicina							26.8		
HYDROZOA									
Aglantha digitale		.03							
Lensia conoidea		.01							
Siphonophore D								.077	
Unidentified	2.86								
OSTEICHTHYES LARVAE									
Glyptocephalus cynoglossus	.152		.092	.32				.004	
Merluccius bilinearis	.152		.302	.746	1.917	3.109	33.44	.011	.187
Urophycis chuss						.242			.094
Species A-1									.094
Species A-2						.121			
OSTRACODA									
Microconchoeua curta	2.86								
PENAEIDAE									
Lucifer sp.							26.8		
POLYCHAETA									
Tomopteris sp.	10.876								
TOTAL BIOMASS/M3	.275	.005	.154	.272	.487	.543	.256	.013	.410

* Small bugs not analysed

** Large bugs not analysed

[1] Immature

ZOOPLANKTON DATA - SCOTIAN SHELF

DATE: 1 September 1976 LAT. 42°39'N LONG. 64°47'W

TOW 11

SAMPLE	1	2	3	4	5	6	7	8	9
MESH	243	1050	243	243	243	243	243	243	243
TIME	2217	2224	2229	2232	2235	2238	2244	2248	2252
DEPTH	100-90	90-80	80-70	70-60	60-50	50-40	40-30	30-21	21-0
VOLTAGE[2]	0	0	0	0	.002	.013	.055	.082	.082
TEMPERATURE	6.9	7.2	7.1	7.6	8.0	12.5	17.0	16.6	16.9
AMPHIPODA									
Parathemisto abyssorum	.2	.32			5.88	10.62			
Parathemisto gaudichaudii		.03							
Unidentified	1.0								
ANTHROZOA									
Unidentified					5.88				
APPENDICULARIA									
Oikopleura sp.					5.88		174.49		98.26
ASTEROIDEA									
Unidentified						10.62			
BIVALVIA									
Mulina sp.			3.52					38.11	
Unidentified	1.0								
BRACHYURA									
Unidentified		.03							
Larvae							.007		
CALANOIDA									
Acartia danae								13.25	
Calanus finmarchicus	94.0	1.7	271.08	197.37	188.07	148.63	8.83		
Calanus hyperboreus		.5							
Calanus sp.[1]		.2	28.16	40.49	23.51	31.85	22.09		32.75
Calocalanus parvus							22.09		
Candacia armata	2.0	.8	10.56	5.06	17.63	21.23	26.50	114.32	32.75
Centropages bradyi			3.52	10.12			26.50	38.11	65.51
Centropages typicus	12.0	1.8	17.6	25.3	52.89	106.17	318.05	2000.56	9433.4
Mecynocera clausi			3.52	15.18					
Metridia longa			7.04	40.49		84.93	13.25		
Metridia lucens	12.0		14.08	15.18	29.39	10.62	8.62	8.83	
Metridia sp.	15.0	.1	116.18	131.58	276.23	456.51	8.83		
Nannocalanus minor	1.0	.5					79.51	266.74	98.20
Paracalanus parvus	2.0			15.18	32.26	127.4	61.84	323.9	1277.44
Pseudocalanus minutes	4.0	28.16	35.43		70.53	63.7	70.68	323.9	360.3
Temora longicornis							8.83		
Temora styliforma								57.16	
Unidentified				5.06					
CARIDEA									
Pandalid		.03							
Pandalus borealis	.006			.102	.182				
CHAETAGNATHA									
Sagitta elegans	.20	.03						95.26	65.51
Sagitta enflata	.10	.03			5.88		4.42		
Sagitta lyra								1.024	
Sagitta tasmanica	.10						4.42		
Sagitta sp.	.492	.093	.221	1.218	.545	1.354	7.505	18.304	11.30
Unidentified				10.12					

TOW 11

SAMPLE	1	2	3	4	5	6	7	8	9
CLADOCERA									
Evadne spinifera								38.11	
CTENOPHORA									
Unidentified		.004							
CYCLOPOIDA									
Corycaeus giesbrechti								19.05	
Corycaeus latus								19.05	
Corycaeus sp.				5.06			8.83	19.05	32.75
Faranula carinata	1.0	.26	3.52		5.88				65.51
Oithona atlantica	3.0	.08	14.08	40.49	41.14	360.96	4.42	57.16	32.75
Oncaea venusta								19.05	
DECAPODA									
Larval shrimp							17.67		
Unidentified shrimp			.010						
EUPHAUSIACEA									
Euphausia krohni							4.42	19.05	32.75
Meganyctiphanes norvegica	.1	.03			11.75				
Thysanoessa inermis	.1	.20					4.42		
Thysanoessa sp.	.1	.03		5.06					
Thysanopoda acutifrons							8.83	19.05	
Unidentified	.134	.121	.221	.244	.182	1.693		.128	
GASTROPODA									
Clione limacina		.06							
Clione sp.	44.0		38.73	5.222	5.88	10.62			
Creseis virgula								19.25	32.75
Limacina retroversa									32.75
HYDROZOA									
Aglantha digitale	.2								
Diphyes dispar								19.05	
Siphonophore D							.339		
Unidentified		.023							
Medusa D				.162					
Unidentified						10.62			
ISOPODA									
Microniscid larvae	3.52								
OSTEICHTHYES LARVAE									
Species A-1							.003		
Glyptocephalus cynoglossus		.004				.042		.064	
Merluccius bilinearis					.006	1.343	11.928	1.024	1.534
Sebastes marinus					.006			.032	
Urophycis chuss	.089								
PENAEIDAE									
Lucifer sp.									32.75
POLYCHAETA									
Tomopteris helgolandica		.06		.244	.818	1.720			
Tomopteris sp.	.313	.112	.166						
Unidentified	.1		3.52						
TOTAL BIOMASS /M^3	.164	.007	.193	.248	.230	.313	.205	.515	.657

[1] Immature

Table 1a. Total number of copepods in each sample.

TOTAL NUMBER OF COPEPODS PER M^3

Tow \ Sample	1	2	3	4	5	6	7	8	9
2	*	**	215.88	0.89	18.66	4.32	556.06	3.52	1628.98
3	119.10	**	214.85	447.20	314.92	110.89	205.81	3836.69	341.29
4	150.83	**	115.58	134.57	80.8	116.42	36.69	365.30	85.77
5	329.86	**	28.04	168.22	526.00	1944.00	510.48	875.00	1041.00
6	***	**	35.40	343.00	186.90	125.75	*	923.00	2606.39
8	135.37	**	301.18	225.62	35.11	629.37	33.91	*	193.16
9	127.74	**	251.21	166.00	1029.59	1839.92	2298.70	6949.32	6282.42
10	489.50	**	362.34	791.16	2691.72	1751.00	3001.44	*	2345.37
11	146.00	**	624.77	546.56	737.53	1412.00	702.33	3258.08	11431.42

* Small bugs not counted

** Coarse mesh net

*** No sample recovered

Table 2. Depth of acoustic scattering layers during the different tows and the animals possibly responsible for the scattering.

Tow	Depth of layer (m)	Possible organism responsible	Calculated S_v from number of animals and their TS	Calculated S_v from voltage
1	125-145	Copepods		
	100	Copepods		
	0-25	Siphonophores		
2	0-14	Copepods		
	14-27	Siphonophores	-59	-60
	75-100	Siphonophores	-67	-67
3	0-25	Copepods, euphausiids and amphipods	-56	-57
	100-150	Siphonopores		
5	20-40	Siphonophores, salps[1], fish larvae, euphausiids	-62	-59
6	15-25	Fish larvae and copepods		
9	20-50	Fish larvae and copepods		
	100	Siphonophores		
10	20-50	Fish larvae and euphausiids		
11	0-30	Copepods, euphausiids and Chaetognaths	-58 or -63	-66

[1]Salps not included due to lack of TS estimates.

[2]Includes copepods, euphausiids and chaetognaths.

[3]Calculated assuming only euphausiids caused scattering.

Table 3. Volume backscattering expressed as dB per m^3 for samples in the different tows. For the depths of the tows see Fig. 1.

	Sample								
Tow	1	2	3	4	5	6	7	8	9
1				-66.30	-65.66	-78.71	-70.26	-	-
2	-73.40	-67.07	-65.17	-66.06	-74.91	-67.37	-62.18	-59.59	-
3	-	-	-	-	-	-	-67.01	-56.57	-
4	-70.51	-	-74.56	-72.69	-73.94	-66.30	-58.62	-66.56	-
5	-	-	-	-	-66.95	-58.75	-50.37	-57.87	-57.04
6	-74.56	-74.91	-	-	-70.26	-60.91	-50.79	-49.41	-
8	-	-	-	-	-	-	-	-	-
9	-56.93	-62.84	-67.25	-67.44	-64.98	-64.21	-61.09	-	-
10	-59.45	-62.48	-67.50	-63.12	-62.08	-61.08	-62.14	-77.92	-63.71
11	-	-	-	-	-	-74.56	-68.30	-66.56	-

Table 4. Percent of frequency of each size class of Merluccius bilinearis in all samples in each tow plus the combined frequency for all tows.

Merluccius bilinearis

Tow - % frequencies

Size(mm)	1	2	3	5	6	8	9	10	11	Combined
30									.186	.042
23					.181					.042
18									.186	.042
16									.186	.042
15				.495		4.545				.126
14	5.714			.990	.181	2.273		.153	.186	.336
13		2.703				6.818			.742	.336
12	2.857	2.703		.990	.181	20.455		.306	.186	.716
11	8.571	5.405		1.980	1.630	25.000			1.113	1.470
10	2.857	8.108		6.436	1.449	27.273	1.866	.459	2.412	2.436
9	2.857	21.622		27.723	3.442	9.091	3.358	1.225	.928	4.620
8	25.714	21.622	1.961	30.198	8.877	4.545	3.731	1.378	2.412	6.804
7	31.429	21.622	3.922	18.317	11.051		2.985	4.135	7.792	8.232
6	5.714	8.108	1.961	2.970	3.080		8.955	11.792	12.616	8.316
5	5.714	8.108	11.765	3.960	16.123		16.045	28.790	12.245	17.010
4	2.857		60.784		49.094		32.090	26.799	27.644	29.945
3	5.714		19.608	5.941	4.710		30.597	23.124	30.983	18.900
2							.373	1.838	.186	.588

Table 5. Percent of frequency of each size class of *Limanda ferruginea*, *Glyptocephalus cynoglossus* and *Urophycis chuss* for all tows.

Limanda ferruginea

Size (mm)	% frequency
24	6.250
23	6.250
17	6.250
16	12.500
15	12.500
14	6.250
13	12.500
12	12.500
11	12.500
10	6.250
9	6.250

Glyptocephalus cynoglossus

Size (mm)	% frequency
42	1.449
33	1.449
30	4.348
28	1.449
27	1.449
26	1.449
25	4.348
24	1.449
23	1.449
22	1.449
21	4.348
20	5.797
19	5.797
18	7.246
17	1.449
16	5.797
15	10.145
14	7.246
13	5.797
12	8.696
11	7.246
10.	2.899
9	4.348
8	1.449
7	1.449

Urophycis chuss

Size (mm)	% frequency
16	.452
11	1.357
10	.452
9	2.262
8	4.072
7	4.977
6	9.955
5	19.457
4	30.317
3	25.339
2	1.357